INDOOR AIR QUALITY REASSESSMENT

John R. Briggs Elementary School
96 Williams Road
Ashburnham, Massachusetts

Prepared by:
Massachusetts Department of Public Health
Bureau of Environmental Health Assessment
January, 2000

Background/Introduction

At the request of Ken Marien, Facilities Manager, for the Ashburnham-Westminster Regional School District, the Massachusetts Department of Public Health (MDPH), Bureau of Environmental Health Assessment (BEHA) provided assistance and consultation regarding indoor air quality concerns at the John R. Briggs Elementary School (the school), 96 Williams Road, Ashburnham, Massachusetts. Mr. Marien reported complaints of periodic mold odors of an undetermined source in classroom 134.

On November 5, 1999, the school was visited by Michael Feeney, Chief of Emergency Response/Indoor Air Quality (ER/IAQ), BEHA, to conduct an indoor air assessment. Mr. Feeney was accompanied by Candice Wright, Vice Principal of the John R. Briggs Elementary School.

The school is a brick and steel structure constructed in 1968. Three classrooms (105, 106 and 107) and offices were added in 1991. Two modular classrooms were added within the last several years. The school contains general classrooms, an art room, library, cafeteria, music room and various offices. Classroom windows are openable.

Methods

Air tests for carbon dioxide were taken with the Telaire, Carbon Dioxide Monitor and tests for temperature and relative humidity were taken with the Mannix, TH Pen PTH8708 Thermo-Hygrometer. Water content of materials in classroom 134 was measured with a Delmhorst, BD-2000 Model, Moisture Detector with a Delmhorst Standard Probe.

Results

This school houses kindergarten through 5th grade, with a student population of approximately 500 and a staff of approximately 60. The tests were taken during normal operations at the school. Test results appear in Tables 1-4.

Discussion

Ventilation

It can be seen from the tables that carbon dioxide levels were elevated above 800 ppm (parts per million) in 22 of 31 areas surveyed, which indicates an overall ventilation problem in this school. Fresh air in classrooms is supplied by a unit ventilator (univent) system (see Figure 1). Obstructions to airflow, such as books, papers and posters on top of univents; and bookcases, tables and desks in front of univent returns, were seen in a number of classrooms. To function as designed, univents and univent returns must remain free of obstructions. More importantly, these units must be activated and allowed to operate.

Exhaust ventilation in classrooms is provided by a mechanical exhaust system. The exhaust vents are located in the upper portions of coat closets in classrooms (see Picture 1). Classroom air is drawn through a space beneath the closet door (see Picture 2). This design allows for these vents to be easily blocked by stored materials on shelves beneath the exhaust vent. In a number of classrooms, these vents were blocked with books, book bags, boxes and other obstructions. The rooftop exhaust vent motors servicing the classrooms were examined (see Picture 3). All of the exhaust vent motors were found inoperable and in need of repair.

The air handling units (AHUs) in the modular classrooms were examined for function. These units did not appear to have fresh air intakes. Each AHU distributes recirculated air by ductwork to ceiling mounted air diffusers. A thermostat controls the operation of each AHU. The AHUs were off during this inspection. Each thermostat was set in the "automatic" setting. Both thermostats have three settings: "on", "off" and "automatic". The "automatic" setting on the thermostat activates the heating, ventilation and air conditioning (HVAC) system at a preset temperature. Once a preset temperature is reached in the area of the thermostat, the HVAC system is deactivated. The thermostat was set on the automatic setting, which had turned off the AHUs. Modular classrooms are designed to be energy efficient, therefore little outside air penetration occurs, except when windows are open.

To maximize air exchange, the BEHA recommends that both supply and exhaust ventilation operate continuously during periods of school occupancy. In order to have proper ventilation with a univent and exhaust system, these systems must also be balanced to provide an adequate amount of fresh air to the interior of a room while removing stale air from the room. The date of the last balancing of these systems was not available at the time of the assessment.

The Massachusetts Building Code requires a minimum ventilation rate of 15 cubic feet per minute (cfm) per occupant of fresh outside air or have openable windows in each room (SBBRS, 1997). The ventilation must be on at all times that the room is occupied. Providing adequate fresh air ventilation with open windows and maintaining the temperature in the comfort range during the cold weather season is impractical. Mechanical ventilation is usually required to provide adequate fresh air ventilation.

Carbon dioxide is not a problem in and of itself at levels measured in this building. It is used as an indicator of the adequacy of the fresh air ventilation. As carbon dioxide levels rise, it indicates that the ventilating system is malfunctioning or the design occupancy of the room is being exceeded. When this happens, a buildup of common indoor air pollutants can occur, leading to discomfort or health complaints. The Occupational Safety and Health Administration (OSHA) standard for carbon dioxide is 5,000 parts per million parts of air (ppm). Workers may be exposed to this level for 40 hours/week, based on a time-weighted average (OSHA, 1997).

The Department of Public Health uses a guideline of 800 ppm for publicly occupied buildings. A guideline of 600 ppm or less is preferred in schools due to the fact that the majority of occupants are young and considered to be a more sensitive population in the evaluation of environmental health status. Inadequate ventilation and/or elevated temperatures are major causes of complaints such as respiratory, eye, nose and throat irritation, lethargy and headaches.

The BEHA recommends that indoor air temperatures be maintained in a range between 70 ^{o} F to 78 ^{o} F in order to provide for the comfort of building occupants. Temperature readings were measured in the school between 69^{o} F to 76^{o} F, which is close to the BEHA recommended range. In many cases concerning indoor air quality, fluctuations of temperature in occupied spaces are typically experienced, even in a building with an adequate fresh air supply.

The relative humidity in this building was within a range of 16 to 33 percent, which is below the BEHA recommended comfort range in all areas. The BEHA recommends a range of 40-60 percent for indoor air relative humidity. Relative humidity levels in the building would be expected to drop during the winter months due to heating. The sensation of dryness and irritation is common in a low relative humidity environment. Low relative humidity is a common problem during the heating season in the northeast part of the United States.

Microbial/Moisture Concerns

As indicated by school personnel, a corner of classroom 134 has experienced periodic mold odor (see Picture 4). The odor is confined to the interior wall opposite the hallway door. No obvious source of moisture exists in this corner that can be attributed to plumbing or roof leaks. No classroom materials, except for the bottom part of the file cabinet (see Picture 5), had signs of water damage. According to school officials, carpets in the classroom are wet cleaned prior to the beginning of school. The mold odor was reported to be present for the first several months of the school year and would dissipate over time. School officials reported that this corner of the carpet (roughly a 4 foot by 10 foot) square was wet cleaned two weeks prior to this assessment. Moisture sampling was done in the carpeting and under the plastic carpet runners. Most areas of carpeting had non-detectable levels of moisture, however moisture measurements beneath the plastic runner in the corner wet cleaned had moisture content measurements of 8 to 25 percent (see Picture 6). Measurable levels of moisture were also found under the plastic runner for a distance of approximately 10 feet from the interior wall (see Picture 7). With the lack of visible sources of water that would moisten carpet, the presence of measurable levels of moisture would indicate that the wet cleaning process is the probable cause of mold growth in this carpet. During late August, early September, Massachusetts is subject to hot, humid weather conditions. The application of a wet cleaning method during this time period may result in the carpeting remaining moist. As weather becomes colder and the heating system is activated, the carpet dries out and the odor dissipates. The further addition of water to the carpeting can result in continuing odors, as mold growth is renewed.

It was discovered that the carpet installed in classroom 134 appears to be backed with a natural material, possibly jute (see Picture 8). Natural materials, like jute, can be susceptible to mold growth if carpeting is allowed to remain moist. If mold has colonized carpeting, the addition of moisture can result in increased mold growth.

The carpet runner was found lifted from the floor surface. It appears that as the carpeting was cleaned, water from this process was injected underneath the carpet runner. Since the carpet runner is water impermeable, this moisture cannot evaporate as rapidly as exposed carpet. Finding measurable levels of moisture beneath the carpet runner with no measurable moisture levels in most areas of the carpet two weeks after wet cleaning would confirm this theory. In addition, the length of carpet runner with measurable water contents roughly corresponds to the area of carpet cleaned two weeks prior to the assessment.

The American Conference of Governmental Industrial Hygienists (ACGIH) recommends that carpeting be dried with fans and heating within 24 hours of becoming wet (ACGIH, 1989). If carpets are not dried within this time frame, mold growth may occur. Water-damaged carpeting cannot be adequately cleaned to remove mold growth. The application of a mildewcide to moldy carpeting is not recommended. Please note that the carpet cannot be readily removed due to the asbestos contents of the tile beneath the carpet. If carpet is removed, all relevant containment precautions to prevent the aerosolization of asbestos from the floor tiles must be taken.

The school also appears to have water penetration through window frames as noted by signs of water damage (see Picture 9). In the guidance office, tiling on the windowsill has curled due to water damage (see Picture 10). Water penetration through window frames can serve as a mold growth medium.

The roof of the portable classrooms is outfitted with a drainage system that is connected to downspouts. Downspouts for this system are not connected to the roof system (see Picture 11), which allows rainwater to impact on the ground below and chronically wet the exterior wall. Downspouts should be designed to direct rainwater away from the base of the portable classroom exterior walls to prevent rainwater from penetrating through the asphalt/exterior wall seam into the classroom crawl space. The wetting of exterior walls and crawlspace soil can result in mold growth.

Several classrooms have sinks that have a seam between the countertop and wall. Water penetration through this seam can result if not watertight. Water can penetrate the countertop seam and collect behind this board. Water penetration and chronic exposure to water on wood, plywood and corkboard cause these materials to swell and serve as a growth medium for mold.

The front courtyard of the school has a wall that has a substantial ivy growth (see Picture 12). The interior wall of the ivy growth was free of signs of water penetration. Clinging plants can cause water damage to brickwork by inserting tendrils into brick and mortar. Water can penetrate into the brick along the tendrils, which can subsequently freeze and thaw during the winter. This freezing/thawing action can weaken bricks and mortar, resulting in damage to this wall. In order to avoid this problem, clinging plants on brickwork is not recommended.

Other Concerns

Several other conditions that can potentially affect indoor air quality were also identified. Accumulated chalk dust was noted in the Modular classrooms. Chalk dust is a fine particulate, which can be easily aerosolized and is an eye and respiratory irritant. A number of areas had missing/dislodged ceiling tiles, and/or cracks/holes in the walls. These areas are breaches of the building envelope, which provide pathways for the movement of odors, fumes, dusts and vapors between rooms and floors.

Several classrooms contained dry erase boards and dry erase board markers. Materials such as dry erase markers and dry erase board cleaners may contain volatile organic compounds (VOCs), such as methyl isobutyl ketone, n-butyl acetate and butyl-cellusolve (Sanford, 1999), which can be irritating to the eyes, nose and throat.

The teacher's restrooms in the front hall have passive door vents. A spring mechanism within the vent frame closes the louvers, which seals these vents. Restrooms are usually designed to have only exhaust vents. This design is meant to keep odors within the restroom by drawing air from the hallway (called transfer air) through the passive vent in the door and into the ceiling mounted exhaust vent. With the door vent spring loaded shut, the draw of transfer air is restricted, which degrades the performance of the exhaust ventilation to remove odors and moisture from these restrooms.

Conclusions/Recommendations

In view of the findings at the time of the visit, the following recommendations are made:

1. Follow the recommendations made in the BEHA letter dated December 23, 1999 concerning removal of the carpet from classroom 134 (MDPH, 1999) (See Appendix 1).
2. Discontinue wet cleaning of carpeting to prevent further mold growth. Evaluate carpeting in other classrooms for mold growth and consider removing carpet in a manner consistent with asbestos remediation laws and regulations.
3. Remove materials blocking the fresh air diffusers or return vents of univents. Univents must remain clear of obstructions in order for the equipment to function properly.
4. In order to improve indoor air quality, an increase in the percentage of fresh air supply into the univent system may be necessary. Survey classrooms for univent function to ascertain if an adequate air supply exists for each room.
5. Repair the exhaust ventilation motors.
6. Examine the feasibility of providing both fresh air supply and exhaust ventilation for the modular classrooms.
7. Clear a three-foot space around all exhaust vents where feasible and reduce stored materials in classroom closets such that airflow is not impeded. Exhaust ventilation is necessary to remove pollutants from the interior of classrooms. If exhaust ventilation cannot be run continuously, adjust exhaust unit ventilator to have exhaust run as much as this equipment will allow.

8. Consider consulting a ventilation engineering firm to evaluate whether the current univent system can provide 15 cubic feet per minute (cfm) as recommended in the American Society of Heating, Refrigerating and Air-Conditioning Engineers (ASHRAE) standard for *Ventilation for Acceptable Air Quality* (ASHRAE, 1989) and the BOCA Mechanical Code (BOCA, 1993).
9. Once both the fresh air supply and the exhaust ventilation are functioning, the ventilation system should be balanced.
10. Door vents in bathrooms should be repaired and blockage removed. Make sure exhaust ventilation is functional to prevent bathroom odors from penetrating halls and classrooms.
11. Replace any remaining water-stained ceiling tiles and wall plaster. Examine the area above and around these areas for mold growth. Disinfect areas of water leaks with an appropriate antimicrobial.
12. Examine windows for water penetration and repair where needed. Remove/replace water damaged wood and tiling. Examine areas underneath water damaged materials for mold growth. Disinfect these areas with an appropriate antimicrobial.
13. Increased dust control in the school would serve to reduce the number of airborne irritants. Use a water soluble, odorless mop treatment to prevent the introduction of volatile organic solvents into the school.
14. For buildings in New England, periods of low relative humidity during the winter are often unavoidable. Therefore, scrupulous cleaning practices should be adopted to minimize common indoor air contaminants whose irritant effects can be enhanced when the relative humidity is low. To control for dusts, a HEPA filter

equipped vacuum cleaner in conjunction with wet wiping of all surfaces is recommended. Drinking water during the day can help ease some symptoms associated with a dry environment (throat and sinus irritations).

15. Reconnect the portable classroom downspouts to the roof drains. Examine the feasibility of directing downspout water away from the base of the portable classroom's exterior wall.
16. Consider replacing the countertop over water-damaged cabinets. Consider using molded countertops to minimize seams where water and dirt can accumulate, thereby decreasing the chance of mold growth.
17. Consider removing clinging vines from the exterior of the building.
18. Remove the springs from the teacher's rest room doors and adjust the passive vent louvers to provide an adequate supply of transfer air.
19. Replace missing or dislodged ceiling tiles to prevent the egress of particulate matter into classrooms.
20. Fill cracks and holes in walls to prevent the movement of odors, fumes, dusts and vapors between rooms.
21. Clean chalkboards and chalktrays regularly to prevent the build-up of excessive chalk dust.

References

ACGIH. 1989. Guidelines for the Assessment of Bioaerosols in the Indoor Environment. American Conference of Governmental Industrial Hygienists, Cincinnati, OH.

ASHRAE. 1989. Ventilation for Acceptable Indoor Air Quality. American Society of Heating, Refrigerating, and Air-Conditioning Engineers, Atlanta, GA. ANSI/ASHRAE 62-1989.

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MDPH. 1999. Letter to Kenneth Marien, Ashburnham-Westminster School District from Michael Feeney, BEHA, Concerning Carpet Removal, Dated December 23, 1999. Massachusetts Department of Public Health, Bureau of Environmental Health Assessment, Boston, MA.

OSHA. 1997. Limits for Air Contaminants. Occupational Safety and Health Administration. Code of Federal Regulations. 29 C.F.R 1910.1000 Table Z-1-A.

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SBBRS. 1997. Mechanical Ventilation. State Board of Building Regulations and Standards. Code of Massachusetts Regulations. 780 CMR 1209.0

The Commonwealth of Massachusetts
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December 23, 1999

Kenneth Marien
Ashburnham-Westminster School District
2 Narrows Road
Westminster, MA 01473

Dear Mr. Marien:

Thank you for your e-mail concerning the indoor air quality assessment conducted on November 5, 1999 at the John R. Briggs Elementary School in Ashburnham, MA. We know that you are anxious to do corrective measures concerning existing conditions in this building. In order to provide you with preliminary information to initiate activities, we are providing you with information concerning the remediation of the carpet in the classroom. As we discussed, we plan to follow up on this letter with a full report concerning the overall assessment of this facility.

During the November 5th assessment, we analyzed the moisture content of the carpet two-weeks after it was cleaned with a water-based method. While no moisture was measured in the carpet, detectable concentrations of moisture (8 percent to 25 percent) were measured under the plastic runner at the edge of the carpet. It appears that the water-based carpet cleaning method utilized injected water underneath the plastic runner. Since the plastic runner is water impermeable, the water is trapped and cannot evaporate as rapidly as the rest of the carpet. This results in the carpet remaining moist and can serve as a means for mold growth. Once a carpet has become colonized with mold, wet cleaning methods are likely to result in enhancing mold growth shortly after the application of water. In this case, removal of the carpet along this plastic runner that was wet cleaned (roughly a 10 feet by 4 feet section at a minimum) is recommended.

As discussed during the visit, caution should be taken when removing this carpet section, since it is adhered to floor tile containing asbestos. All relevant asbestos containment procedures mandated by Massachusetts and federal laws and regulations should be followed when removing this carpet. Consideration should be given to removing the entire carpet. This may be more cost effective since mold growth could be beyond the area cleaned, which may require further removal of carpet sections using asbestos abatement procedures.

Two other important conditions were noted that should be repaired.

1. The majority of rooftop-mounted exhaust ventilation motors were either deactivated or broken. Each of the motors should be repaired and/or reactivated to provide exhaust ventilation in all classrooms.
2. The gutter system for the modular classrooms does not have downspouts to direct rainwater from the base of this structure. Downspouts should be replaced to prevent water penetration.

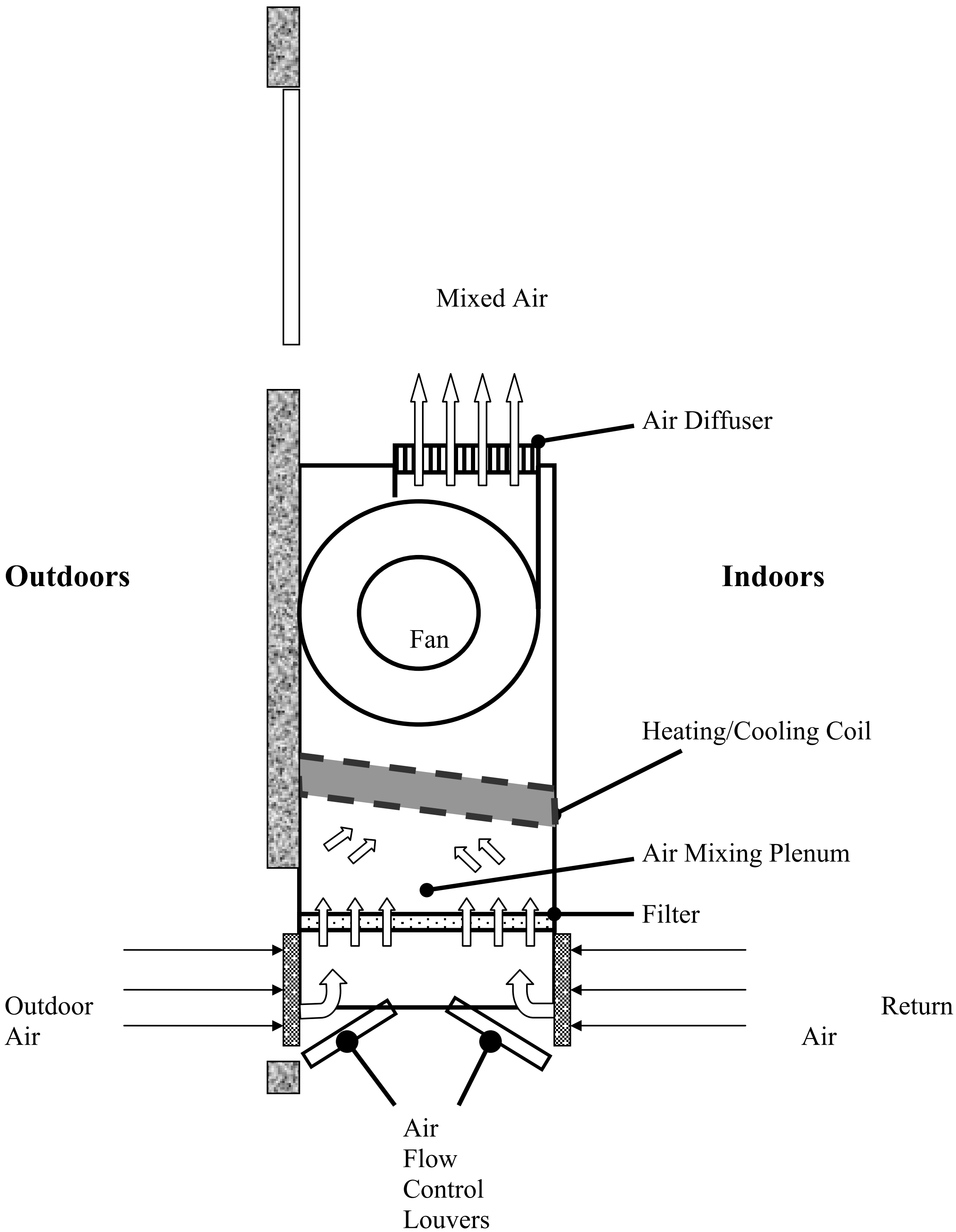
I hope you find this information useful. Please feel free to contact us at (617) 624-5757. A full report concerning the indoor air quality assessment is in preparation and will be forwarded to you upon completion. We hope you find this preliminary information helpful.

Sincerely,

Michael A. Feeney, R.Ph., J.D., C.H.O.
Chief, Emergency Response/ Indoor Air Quality
Bureau of Environmental Health Assessment

cc/ Suzanne Condon, Dir., BEHA
Elaine Krueger, Chief, Env. Tox., BEHA
Cory Holmes, ER/IAQ, BEHA
Suzan Donahue, ER/IAQ, BEHA

Figure 1 **Unit Ventilator (Univent)**



1. Air Flow

← = Fresh Air/Return Air

⇦ = Mixed Air

1.1. Picture 1

Exhaust Vent

2. Exhaust Vent in the Ceiling of the Classroom Closet

2.1. Picture 2

Space Under Door Closet Door

Exhaust Vent Located in Closet

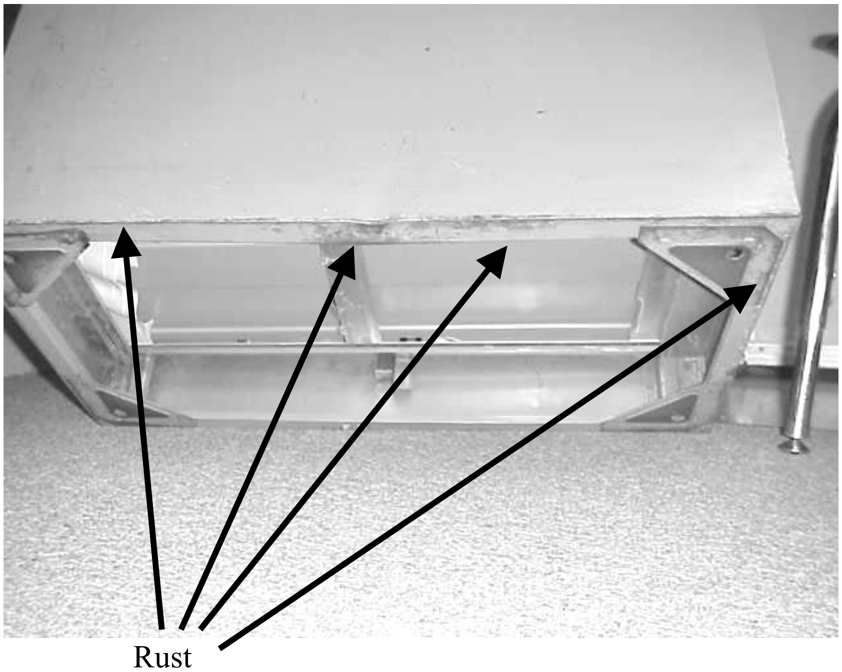
Picture 3

Inoperable Exhaust Vent Motors On Roof

Picture 4

Corner Of Classroom 134 With Reported Mold Odors

Picture 5



File Cabinet in Room 134 Over Moistened Carpeting,
Note Rust on Underside of File Cabinet In Contact With Carpet

Picture 6

Moisture Meter Reading Water Content of the Space beneath the Plastic Carpet Runner

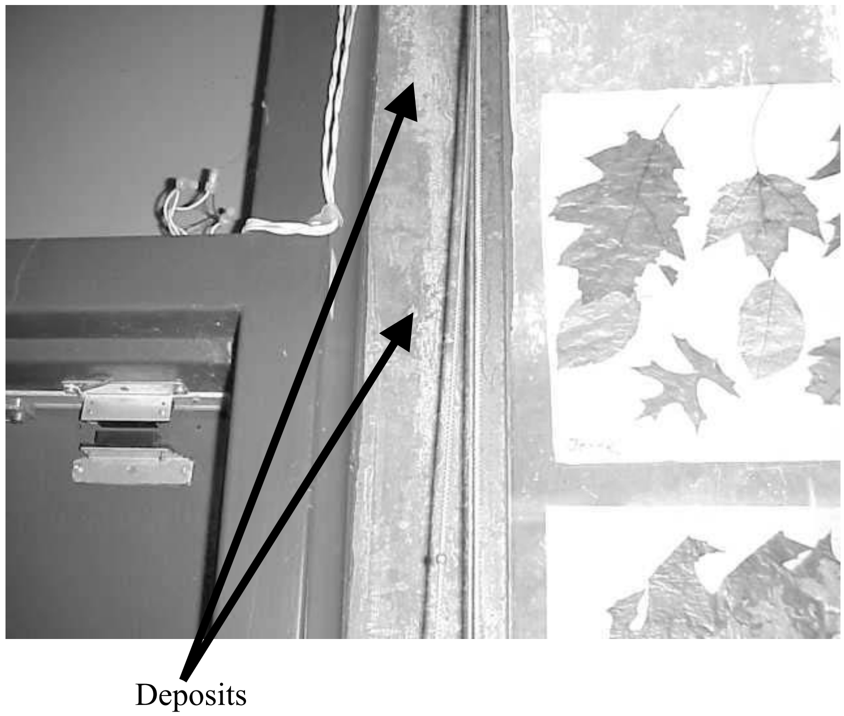
Picture 7

Length of Carpet Runner with Measurable Levels Of Moisture (Approximately 10 Feet)

Picture 8

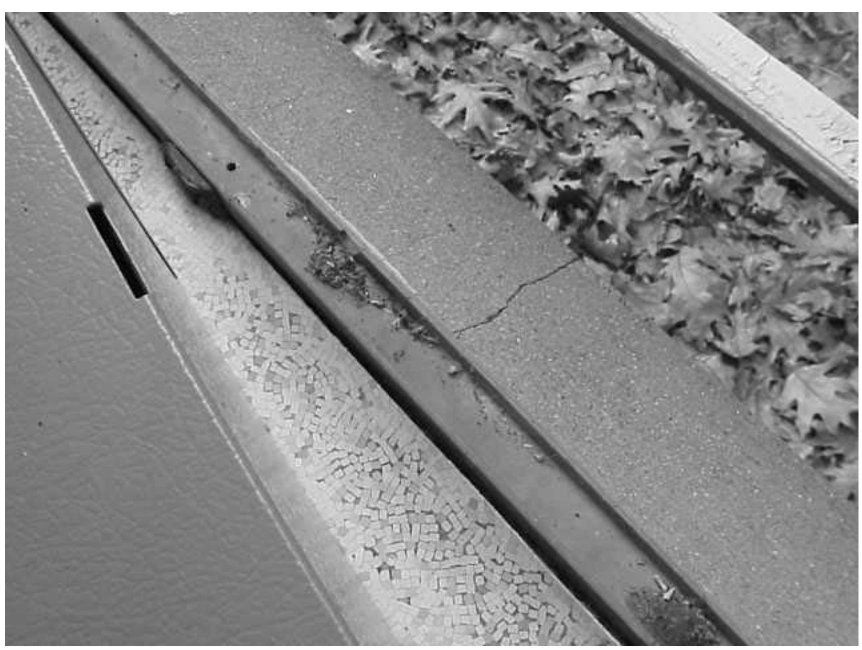
Jute-Backed Carpeting in Classroom 134

Picture 9



Dried Water Deposits in Interior of Classroom Window Frames

Picture 10



Curling Tile on Window Sill

Picture 11

Gutters Missing Downspouts on Modular Classrooms

Picture 12

Ivy Growing on the Exterior of the J. R. Briggs Elementary School

Remarks	Carbon Dioxide *ppm	Temp. °F	Relative Humidity %	Occupants in Room	Windows Openable	Ventilation		Remarks
						Intake	Exhaust	
Outside (Background)	455	57	23					
Art Room	1026	74	22		yes	yes	yes	closet exhaust-off, univent blocked by table
Men's Restroom						no	yes	passive vent louvers-spring loaded-closed, lysol odor
Room 111 (Library)	874	72	19	20	yes	yes	no	passive door vents
Room 125	1008	73	21	18	yes	yes	yes	exhaust-off, door open
Room 125	1028	73	21	21	yes	yes	yes	exhaust-off, univent blocked by table, door open, cleaner
Room 123	684	71	16	18	yes	yes	yes	exhaust off, water damaged sink, cleaner
Room 122	643	71	19	19	yes	yes	yes	water damage around sink/window, spray cleaner
Room 121	1661	72	26	18	yes	yes	yes	supply and exhaust-off
Cafeteria	797	76	20	150+				
Room 129	611	72	21	26	yes	yes	yes	supply and exhaust-off, onion odor, door open
Room 130	1481	73	30	21	yes	yes	yes	exhaust-off, coke cans, door open
Room 131	1373	74	23	20	yes	yes	yes	exhaust-off

Remarks	Carbon Dioxide *ppm	Temp. °F	Relative Humidity %	Occupants in Room	Windows Openable	Ventilation		Remarks
						Intake	Exhaust	
Modular W	612	69	23	20	yes	yes	yes	supply and exhaust-off, 3CT, door open, chalk dust
Modular E	1498	71	33	19	yes	yes	yes	supply and exhaust-off, window open, plants, chalk dust
SPED Workroom	804	73	23	3	no	yes	yes	exhaust-off
SPED Classroom	730	72	19	5	yes	yes	yes	
Room 105	721	72	21	22	yes	yes	yes	1CT
Room 106	821	73	24	22	yes	yes	yes	univent blocked by shelf, chemistry set
Music Room	1128	73	26	18	yes	yes	yes	univent off
Gym	571	69	19	0	yes	yes	yes	supply and exhaust-off
Room 120	1248	73	25	18	yes	yes	yes	exhaust-off, water damaged sink
Room 119	844	70	22	0	yes	yes	yes	exhaust-off, door open
Room 118	978	72	22	19	yes	yes	yes	exhaust-off, door open
Room 117	1214	72	25	19	yes	yes	yes	exhaust-off, univent blocked by shelf, water damaged sink/window
Room 116	1171	71	26	20	yes	yes	yes	exhaust-off

Remarks	Carbon Dioxide *ppm	Temp. °F	Relative Humidity %	Occupants in Room	Windows Openable	Ventilation		Remarks
						Intake	Exhaust	
Guidance Office	741	72	17	0	yes	yes	yes	exhaust-off
Room 126	1281	73	24	24	yes	yes	yes	exhaust-off, univent blocked by desk
Room 135	1692	72	30	21	yes	yes	yes	supply and exhaust-off
Room 134	1180	72	24	0	yes	yes	yes	exhaust-off, mold odor
Room 127	1381	72	25	23	yes	yes	yes	exhaust-off
Room 133	1148	72	24	22	yes	yes	yes	exhaust-off, water damaged sink, door open
Room 132	1201	72	26	20	yes	yes	yes	exhaust-off, univent blocked